Menlo Park Notebook #224 [N-81-01-29]

This notebook covers the period January-May 1881. The entries are by Charles L. Clarke and relate to tests of steam engines and to the design of the Porter-Allen engine for the central station dynamos. The label on the front cover is marked "Steam Engine Tests" and "C.L. Clarke." The book contains 254 numbered pages. The pagination is irregular. Between pages 20 and 21 is a set of 26 pages numbered 00 through 19a.

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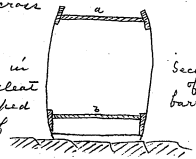
xE-172 N-81.01.29

Test of Jan. 29th 1881.

Water measured from two barrels into which it is pumped by hand and from barrels to boiler, through a Bourgman heater by a Knowles pump.

Two cleats across each barrel (a and b)

Water filled in to bottom of cleat a and pumped out to top of cleat b.



Section of barrel.

No. of Barrel	Total Weight to top of cleat b lbs.	Total Weight to bottom of cleat a. lbs.
1	115	445
2	100	462

Weight of Water { No. 1 = 330, No. 2 = 362 } Temp. 54°F.

May 25. 1881
Clarke

The Porter-Allen engine now in course of construction has cyl 11" x 16" and is to develope 125 H. P. at 350 revo. per minute.

$$\begin{array}{r} 125 \\ 33000 \\ \hline 375000 \\ 375 \\ \hline 4125000 \end{array}$$ ft. lb.

If x is mean effective pressure

$$\left(95.033 - \frac{2.4052}{2}\right) x \times \frac{16}{12} \times 350 \times 2 = 4125000$$

$$x = 47.1 \text{ lbs.}$$

= mean effective pressure.

The clearance is 7% of the piston displacement

∴ let

$C = .07 \times 16 = 1.12$

pressure $= p = 120$ lbs. ~~[illegible]~~
$= 134.7$ absolute

Area piston $= A = 95.033$ sq. in. $- 1.2026$ half the piston rod
$= 93.830$

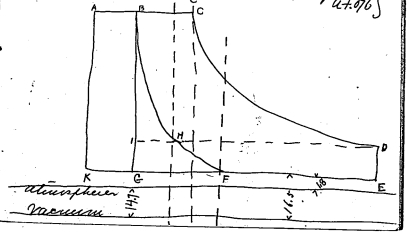
Stroke $= l = 16''$

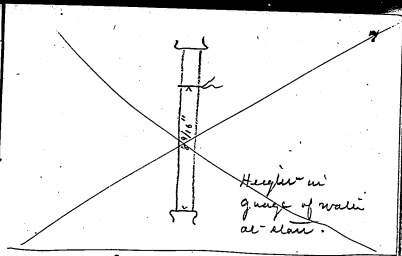
Admission $= a$

$$\text{Work} = Ap\left\{a + (a+c)\log\frac{l+c}{a+c}\right\}$$

$$C = .07l$$

$$\text{Work} = Ap\left\{a + (a+.07l)\log\frac{1.07l}{a+.07l}\right\}$$





BCDEG represents this work but there must be subtracted from it BFG for compression.

The initial pressure KA is 134.7 lbs. and terminal pressure of compression curve at F is 16.5 lbs. therefore the distance $KF = \frac{134.7}{16.5} \times KG$

and $KG = .07\,l = 1.12''$

$\therefore \quad KF = 9.1433''$

And $GF = 9.1433 - 1.12 = 8.0233''$

The mean pressure from G to F on curve B F is

$$CP \times \frac{\log \left(\frac{KF}{C}\right)}{\log \left(\frac{C}{\ }\right)} \div GF =$$

$$1/2 \times 134.7 \times 2.1005 \div 9.1433$$

$$= 33\tfrac{1}{2} \text{ lbs.}$$

The work absorbed in ~~B F C~~ is $APC \log \frac{KF}{C} =$

$$\frac{95.033 \times 134.7 \times 1.12}{12} \times \log \frac{9.1433}{1.12}$$

$$= 2509.55 \text{ ft. lbs.}$$

and for 700 reciprocations

$$= 1756687 \text{ ft. lbs.}$$

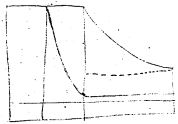
Therefore the curve B C D E G must give

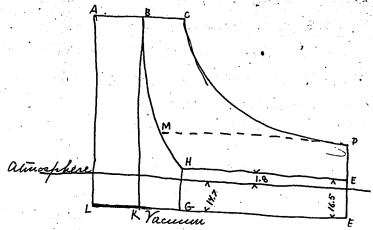
$$4125000 + 1756687$$

$$= 5881687 \text{ ft. lbs.}$$

The total work from K to F.

$$= A p c \log \frac{KF}{c}$$





~~The total work from~~

Piston Area = 95.033

" rod area = 2.4052

True Piston Area = 93.8304 = A

Stroke = 16" = l

Admission = a

Clearance = (.07)l = 1.12 = c

Absolute Pressure = 134.7 = p

The initial pressure at BK being 134.7 and terminal pressure of curve BH 16.5 lbs.

$$LG : LK :: 134.7 : 16.5$$

$$LG = \frac{LK \times 134.7}{16.5}$$

$$= 9.1433$$

$$\therefore KG = 8.0233$$

Total Work from K to G for 1 stroke

$$= ApC \log. \frac{LG}{C}$$

$$= 93.83 \times 134.7 \times \frac{1.12}{12} \times 2.\text{f}$$

$$= \cancel{2370.68} \ 2477.224 \text{ ft. lbs.}$$

and for 700 reciprocations

$$= \cancel{1659476} \ 1734057 \text{ ft. lbs.}$$

~~The remaining~~ this work is for compression and against the atmosphere from G to K

The remaining amount of work against the atmosphere is

$$HG \times GF \times A \times \cancel{\text{[illegible]}} \times 700$$

$$= 16.5 \times \frac{7.9767}{12} \times 93.83 \times \cancel{\text{[illegible]}} \times 700$$

$$= 720\,389 \text{ ft. lb.}$$

The total resistance in work excepting the external wire be

$$720\,389 + \cancel{1659476}\ 1734057$$

$$= \cancel{2379865}\ 2454445 \text{ ft. lb.}$$

To do 125 H. P. of external work there must be added 4125000 ft. lb. making a total of

$$\cancel{6504865}\ 6579445 \text{ ft. lb.}$$

Suppose we cut off at $\frac{7}{10}$ th. stroke.

Total Work

$$= Ap\left[a+(a+.07l)\log\frac{1.07l}{a+.07l}\right]$$

$A = 93.83$
$p = 134.7$
$a = 3''.2$
$.07l = c = 1''.12$

Total Work

$$= 93.83 \times 134.7\left[\frac{3''.2}{12}+\left(\frac{4''.32}{12}\right)1.377\right]$$

$= 9635.778$ ft. lbs. for one stroke and for 700 reciprocations

$= 6745045$ ft. lbs.

subtract ~~2745445~~ ft. lbs.

$= \cancel{4299600}$

$= \cancel{132.3}$ H.P. effective

130

00.

$$DF \times LE = AC \times AL$$

$$DF = \frac{AC \times AL}{LE}$$

$$DF = \frac{134.7 \times 4.32}{17.12}$$

$$DF = 34 \text{ lbs.}$$

Terminal Pressure = 19.3 lb. above atmosphere.

If there had been no clearance

$$DF = \frac{134.7 \times 3.2}{16}$$

Terminal Pressure = 26.94

= 12.24 above atmosphere.

Also the amount of latent work done would be

$$= A p a \left\{ 1 + \log \frac{l}{a} \right\}$$

$$= 93.83 \times 134.7 \times \frac{3.2}{12} \left\{ 1 + 1.6094 \right\}$$

= 8794.65 ft. lbs. and

for 700 reciprocations

= 6156257 ft. lbs.

and subtract from this the resistance of atmosphere and back pressure during stroke (for there will be theoretically no compression with no clearance)

Resistance

= HG × KF × A × 700

= 1444982 ft. lbs.

leaving 6156257 − 1444982

= 4711275 Total external work

= 142.8 H.P.

Thus in the two cases with equal amounts of steam the power developed without clearance is

142.8 H.P.

With clearance 7%

130 H.P.

or a loss of 9%.

Suppose an admission of $\frac{3}{10}$ of the stroke = 4.8" at 80 lbs. initial above atmosphere or total of 94.7 lbs.

Initial pressure at BK being 94.7 and terminal pressure of curve BH 16.5 lbs.

$$LG = \frac{LK \times 94.7}{16.5}$$

$$= 6.429''$$

$$\therefore \quad KG = 5.309''$$

Total work from K to G for one stroke

$$= A\,p\,c \log \frac{LG}{c}$$

$$= 93.83 \times 94.7 \times \frac{1.12}{12} \times 1.7875$$

$$= 1449.258 \text{ ft-lbs.}$$

and for 700 reciprocations 3

= 1014480 ft. lb.

This work is for compression and against the atmosphere from G to K.

The remaining work against the atmosphere is

HG X GF X A X 700

= 720389 ft. lb.

The total resistance in work excepting the external will be

720389 + 1014480

= 1734869 ft. lb.

To do 125 H.P. of external work there must be added 4125000 ft. lb. making a total of

5859869 ft. lb.

Suppose we cut-off at 3/10 of the stroke

Total Work

$$= Ap\left[a+(a+.072)\log\frac{.072}{a+.072}\right]$$

$A = 93.83$

$p = 94.7$

$a = 4.8''$

$.072 = c = 1''.12$

Total Work

$$= 93.83 \times 94.7\left[\frac{4.8}{12}+\left(\frac{5.92}{12}\right)1.062\right]$$

8209.675 ft. lbs. for one stroke, and for 700 reciprocations

= 5746772 ft-lbs.

Subtract 1734869

= 4011903

= 121.6 H.P.

Suppose we cut off at $\frac{37}{100}$ stroke

$A = 93.83$
$p = 94.7$
$a = 4.96$
$c = 1.12$

Total Work

$$= 93.83 \times 94.7 \left[\frac{4.96}{12} + \left(\frac{6.08}{12} \right) 1.0367 \right]$$

$= 5322.294$ ft. lb. for 1 stroke

and for 700 reciprocations

$= 3725606$ ft. lb.

Subtract 1734869

$= 4090737$ ft. lb.

$= 124$ H.P.

Suppose we cut-off at $\frac{315}{1000}$ stroke

$A = 93.83 \cdot p = 94.7$

$a = 5.04''$ $c = 1.12$

Total Work $= 93.83 \times 94.7 \left[\frac{5.04}{12} + \left(\frac{6.16}{12}\right) 1.0222 \right]$

$= 8378.58$ ft-lbs for 1 stroke

and for 700 reciprocations

$= 5865000$ ft-lbs.

per minute 1734869

$= 4130141$

$= 125$ H.P.

Suppose we cut off at

$\frac{33}{100}$ of stroke

$a = 5.28''$

Force Work =

$$93.83 \times 94.7 \left[\frac{5.28}{12} + \left(\frac{6.4}{12} \right) \overset{98395}{\cancel{11765}} \right]$$

$= \overset{85572.66}{\cancel{94464}}$ ft-lb. for 1 stroke

for 700 reciprocations

$= \overset{6000086}{\cancel{6638470}}$ ft. lb.

subtract 1734869

$= \overset{4265993}{\cancel{4404101}}$

$= \cancel{1456}$ H.P.

129.27 H.P.

Outside work.

Suppose we cut off at $\frac{32}{100}$

$C = 5'.12''$

Work =

$$93.83 \times 94.7 \left[\frac{5.12}{12} + \left(\frac{6.24}{12}\right) 1.009 \right]$$

$= 8453.$ ft. lbs. for 1 stroke

and 700 reciprocations

$= 5917324$ ft. lbs.

Subtract 1734869

$= 4182455$

$= 126.7$ H. P.

See page 11a where the cut off is $\frac{33}{1000}$ of stroke.

$$DF = \frac{AC \times AL}{LE}$$

$$DF = \frac{94.7 \times 6.4}{17.12}$$

$$DF = 35.4$$

Terminal pressure above atmosphere

20.7

If there had been no clearance

$$DF = \frac{94.7 \times 5.28}{17.12}$$

$$DF = 29.2$$

Terminal pressure above atmosphere

14.5

Also total amount of work done $= Apa\left\{1 + \log \frac{r}{a}\right\}$

$$= 93.83 \times 94.7 \times \frac{5.28}{12}\left\{1 + 1.1056\right\}$$

= 8244 ~~reciprocations~~

for 1 stroke

= 5770800 ft.lb. for

700 revolutions.

deducting the atmosphere and

back pressure work –

1444982 ft.lb.

= 4325818 ft.lb.

= 131 h.p.

With clearance the developement was 129.27 H.P

a loss of 2%.